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# RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

## WIND-TUNNEL INVESTIGATION OF A FULL-SCALE MODEL OF THE HUGHES MX-904 MISSILE

By

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# NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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## SUMMARY

A wind-tunnel investigation has been conducted to determine the stability and control characteristics of a full-size model of the Hughes MX-904 missile. Aerodynamic characteristics of the complete model through moderate ranges of angles of attack and yaw, with an additional test made through an angle of attack of 180°, are presented. The effects of horizontal tail deflection are also included.

## INTRODUCTION

At the request of the Air Materiel Command, U. S. Air Force, an investigation of the stability and control characteristics of a full-scale model of the Hughes MX-904 missile was conducted in the Langley 300 MPH 7- by 10-foot tunnel.

The tests were generally made with the wings and tails set at 0° with respect to the fuselage of the missile, at a dynamic tunnel pressure $q$ of 159 pounds per square foot, and covered a range of 0° to 12° of pitch and -5° to 15° of yaw. An additional test at a value of $q$ of 180 pounds per square foot was made through a range of yaw of 0° to 180°. Abbreviated pitch tests were also made with the horizontal tail surfaces deflected 5° and 10°.

## SYMBOLS

The system of axes used for the presentation of the data, together with an indication of the positive forces, moments, and angles, is presented in figure 1. Pertinent symbols are defined as follows:

| | |
|---|---|
| $C_L$ | lift coefficient (Lift/qA) |
| $C_D$ | drag coefficient (Drag/qA) |
| $C_Y$ | lateral-force coefficient (Lateral force/qA) |
| $C_m$ | pitching-moment coefficient (Pitching moment/$ql$A) |
| $C_n$ | yawing-moment coefficient (Yawing moment/$ql$A) |
| $C_l$ | rolling-moment coefficient (Rolling moment/$ql$A) |
| $q$ | dynamic pressure, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$ |
| $\rho$ | air density, slugs per cubic foot |
| $V$ | free-stream velocity, feet per second |
| $A$ | maximum cross-sectional area (0.223 $ft^2$) |
| $l$ | maximum body diameter (0.533 ft) |
| $\alpha$ | angle of attack of missile center line, degrees |
| $\psi$ | angle of yaw of missile center line, degrees |
| $\delta_s$ | angle of horizontal tail deflection, degrees |

## MODEL AND APPARATUS

The full-size model used in these tests was designed and constructed for uncontrolled flight tests. For the tunnel investigation, the propulsion equipment and control equipment were removed. A sketch of the model, with principal dimensions, as mounted in the tunnel on the vertical support strut, is presented in figure 2.

For tare tests, a dummy fairing, similar in dimensions to the streamline fairing on the vertical support strut, was mounted from the ceiling in the same plane as that of the support strut. A wood dummy strut-support fitting was mounted on top of the missile and extended approximately 3 inches into the dummy fairing.

## TESTS AND RESULTS

For the test through an angle of yaw of $0^\circ$ to $180^\circ$ at an angle of attack of $0^\circ$, the tunnel dynamic pressure $q$ was maintained at a value of 180 pounds per square foot, which corresponds to a Mach number of 0.36. Because of difficulty encountered when obtaining tares at a $q$ of 180 pounds per square foot, subsequent tests were made at a $q$ of 159 pounds per square foot with a corresponding Mach number of 0.33.

Inasmuch as the model was a full-size flight missile, the test Reynolds number at any specific Mach number was approximately the flight Reynolds number for that Mach number. Based on the maximum missile-body diameter of 0.533 foot, the Reynolds number for a Mach number of 0.36 is approximately 1,280,000. The Reynolds number for a Mach number of 0.33 is 1,190,000.

Force and moment coefficients presented in this paper are believed to be accurate within ±0.03 and ±0.1, respectively. The degree of accuracy is based on the inherent accuracy in the tunnel balance system and on the dimensional and angular accuracy maintained in the model installation. The accuracy of these data is not as good as usual for this type of tests because the tunnel setup was planned for measuring forces and moments at large angles of yaw and was completed prior to request for data at small angles of pitch and yaw.

The general aerodynamic characteristics of the missile are presented in figures 3 and 4, and the effects of deflection of the horizontal tail surfaces on these characteristics are presented in figure 5.

The data indicate for angles of yaw of $-5^\circ$, $0^\circ$, and $5^\circ$, a neutral or unstable condition for an angle-of-attack range from $8^\circ$ to $12^\circ$. Although the breaks in the pitch curve in this range are of a magnitude equal to or less than the expected over-all accuracy of these data, cross plots of $C_n$ against $\psi$ further substantiate the trend toward instability in the $8^\circ$ to $12^\circ$ range, as do several other curves of incomplete data not presented in this paper.

An unstable condition is also indicated for an angle-of-attack range of $40^\circ$ to $50^\circ$, after which the missile is essentially stable through a pitch or yaw range to approximately $120^\circ$ where it becomes unstable and remains so through the $180^\circ$ or reversed flight range.

The abbreviated tests made to determine the effect of horizontal tail deflection on the aerodynamic characteristics of the missile (fig. 5) indicate large incremental increases in negative pitching moment and positive lift with positive tail deflection.

Inasmuch as this model is symmetrical with respect to the horizontal and vertical reference planes, the variation of $C_L$ and $C_m$ with $\alpha$ and of $C_Y$ and $C_n$ with $\psi$ is presented in figure 6. The curves of figure 6 have been adjusted to indicate zero moment at $0^\circ$ angle of attack and yaw and the size of the symbols used in plotting is indicative of the relative accuracy of the data. Discrepancies between the two curves can be attributed to misalinement in the air stream or in the model and to difficulty in obtaining true tares.

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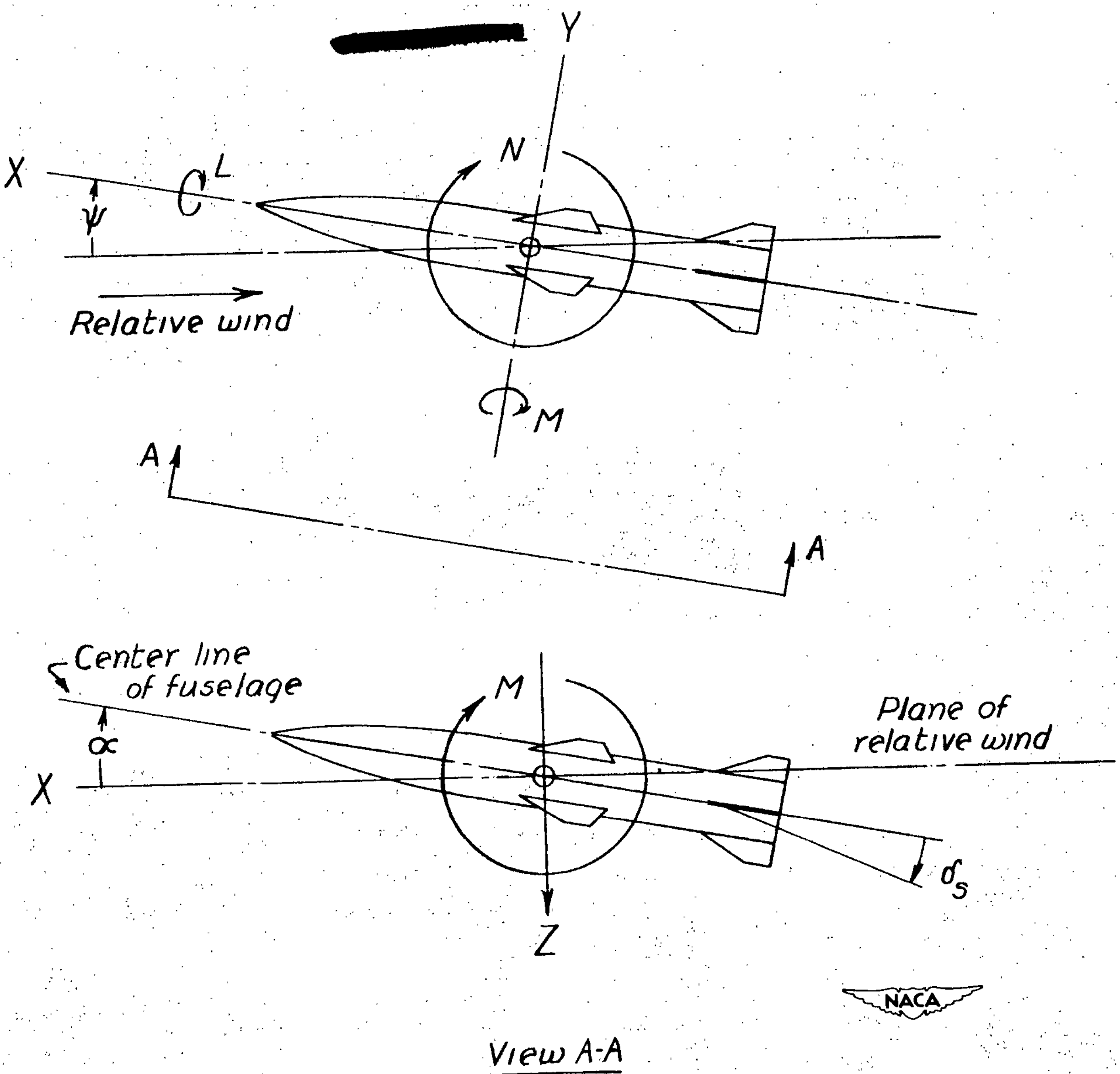


Figure 1.– System of axes and control–surface deflections. Positive values of moments, forces, and angles are indicated by arrows.

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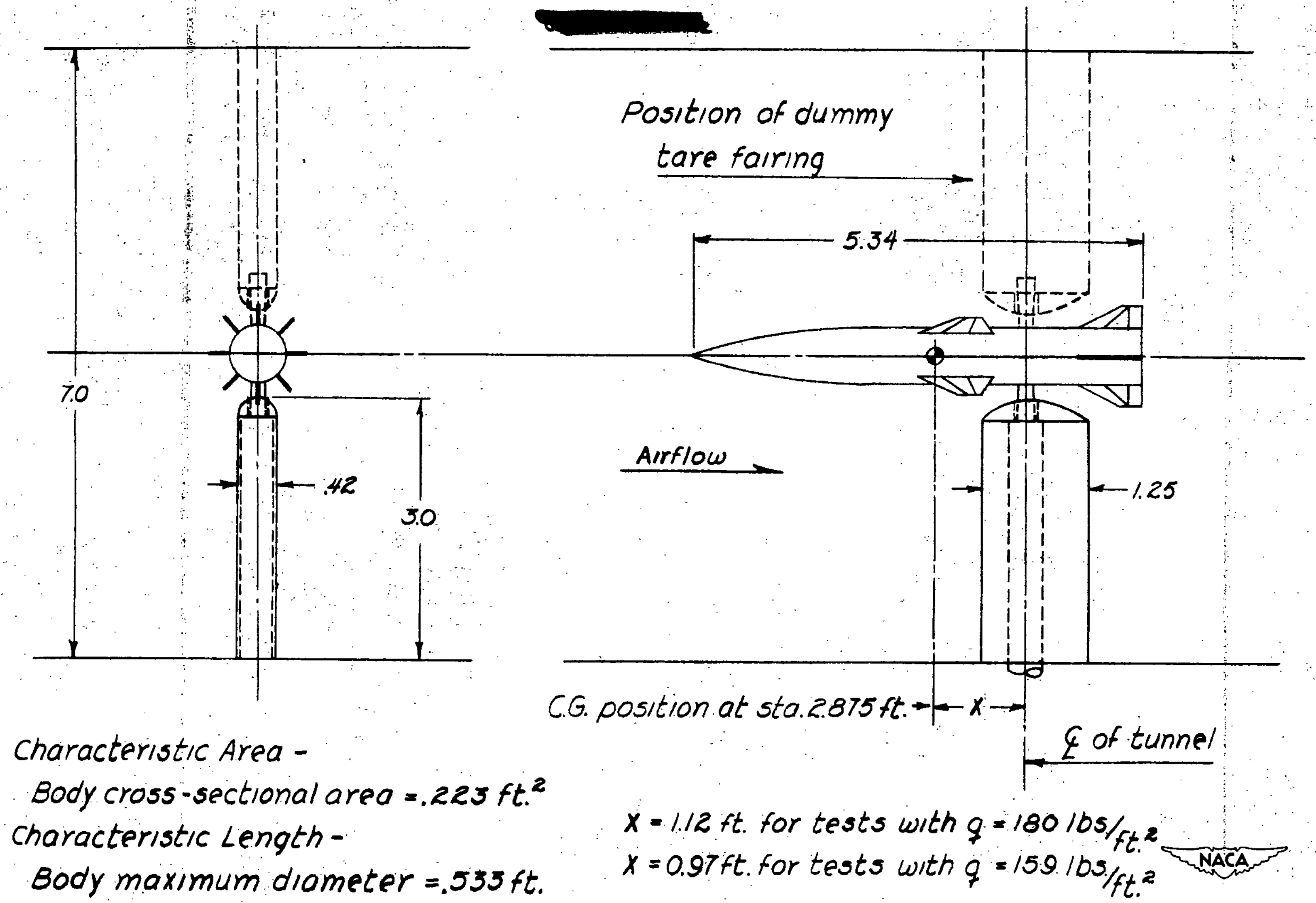


Figure 2.– Sketch of the MX–904 missile as mounted on the vertical support strut in the Langley 300 MPH 7– by 10–foot tunnel. (All dimensions in ft.)

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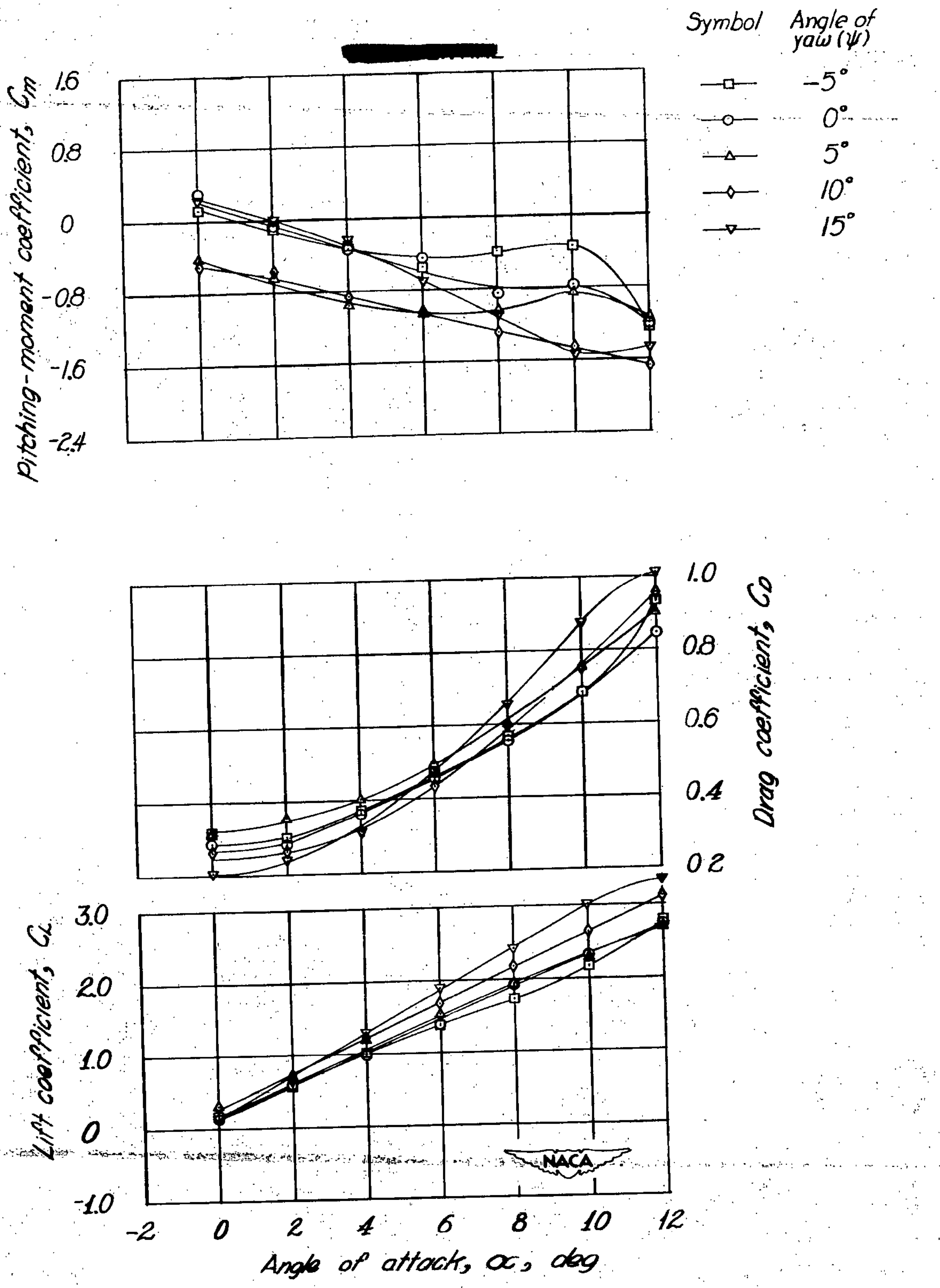


Figure 3.– Aerodynamic characteristics in pitch for the MX-904 missile. q = 159 pounds per square foot.

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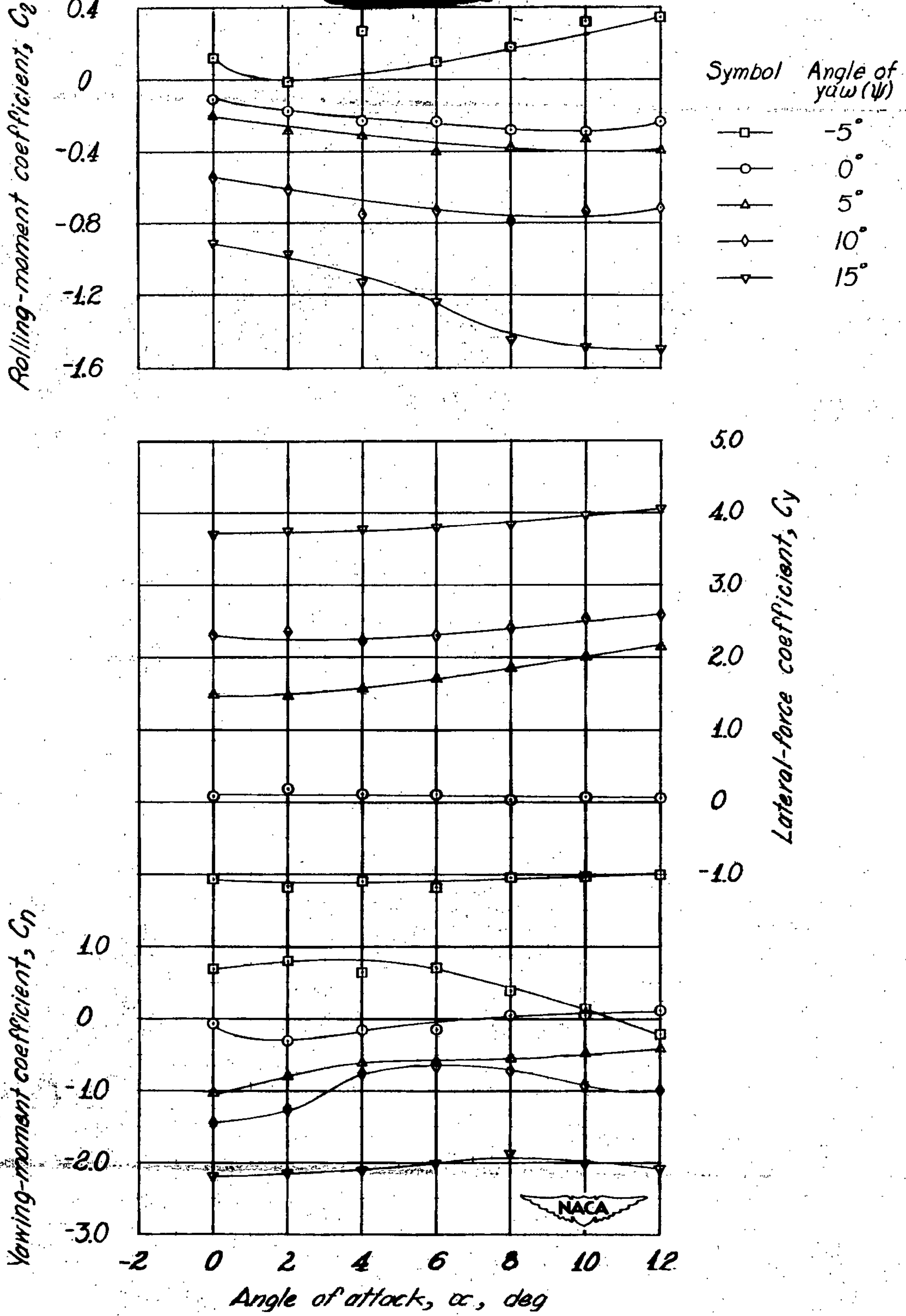


Figure 3.- Concluded.

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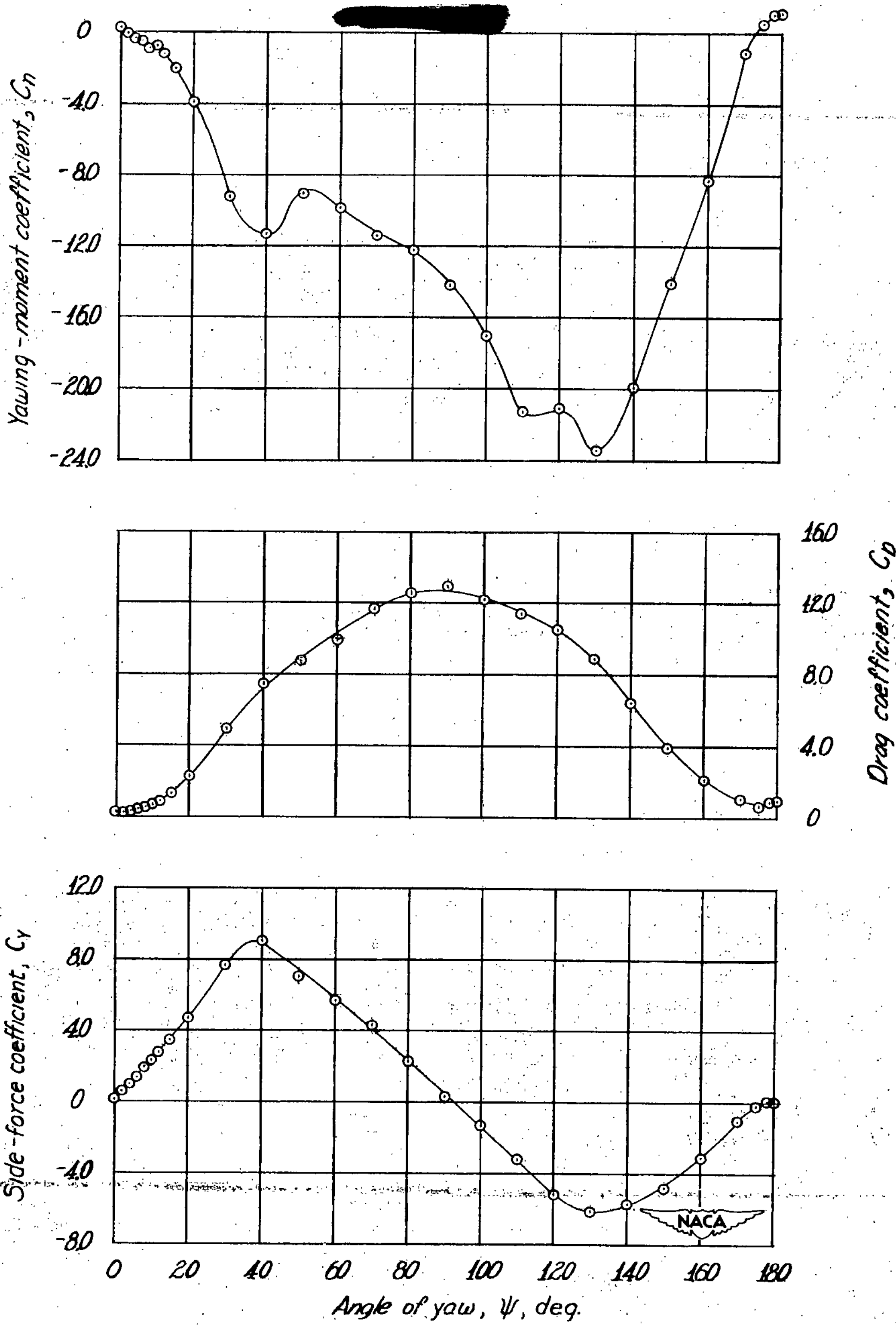


Figure 4.– Aerodynamic characteristics in yaw for the MX-904 missile. q = 180 pounds per square foot.

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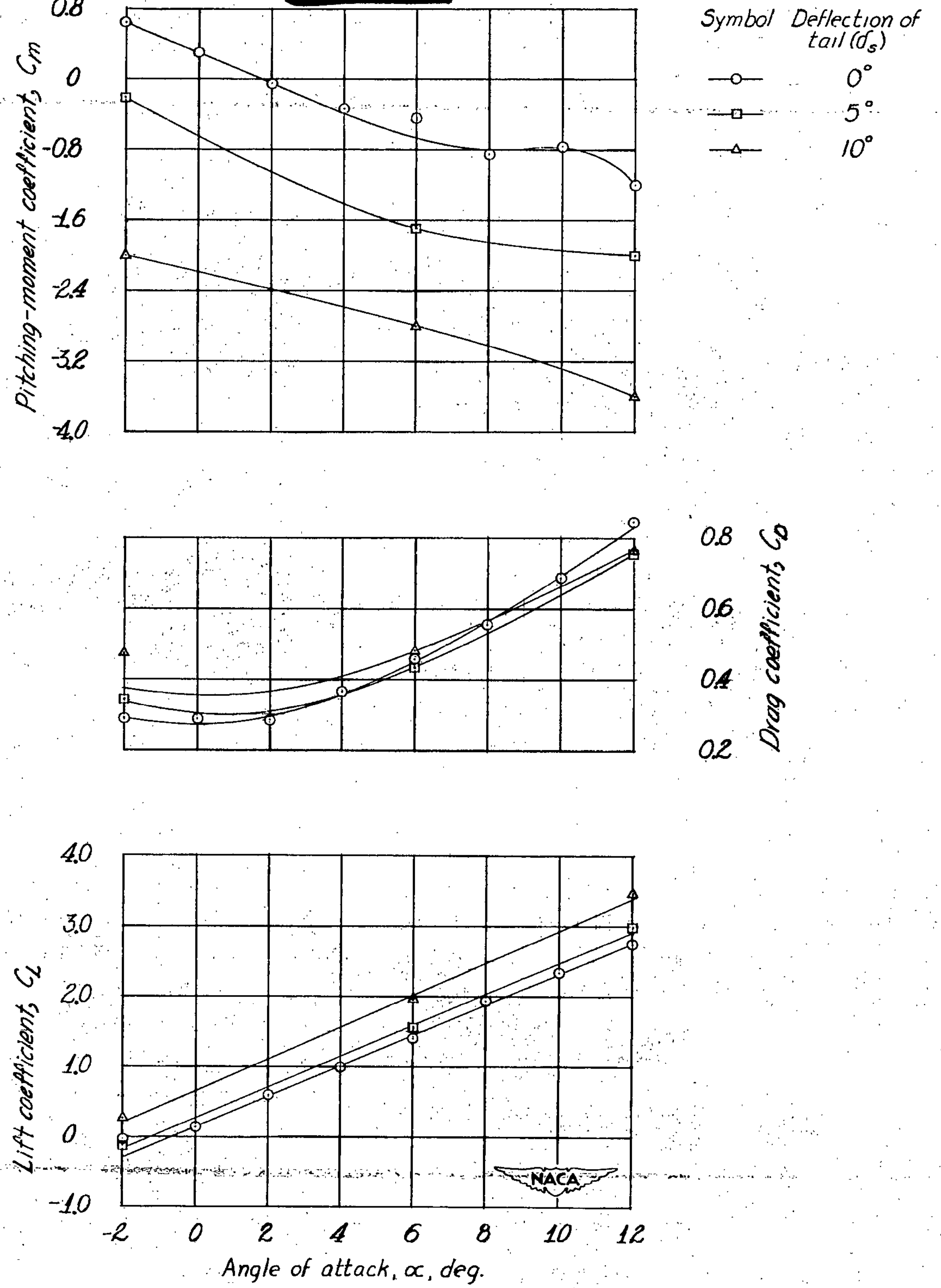


Figure 5.— Variation of aerodynamic characteristics in pitch with horizontal tail deflections for the MX-904 missile. q = 159 pounds per square foot.

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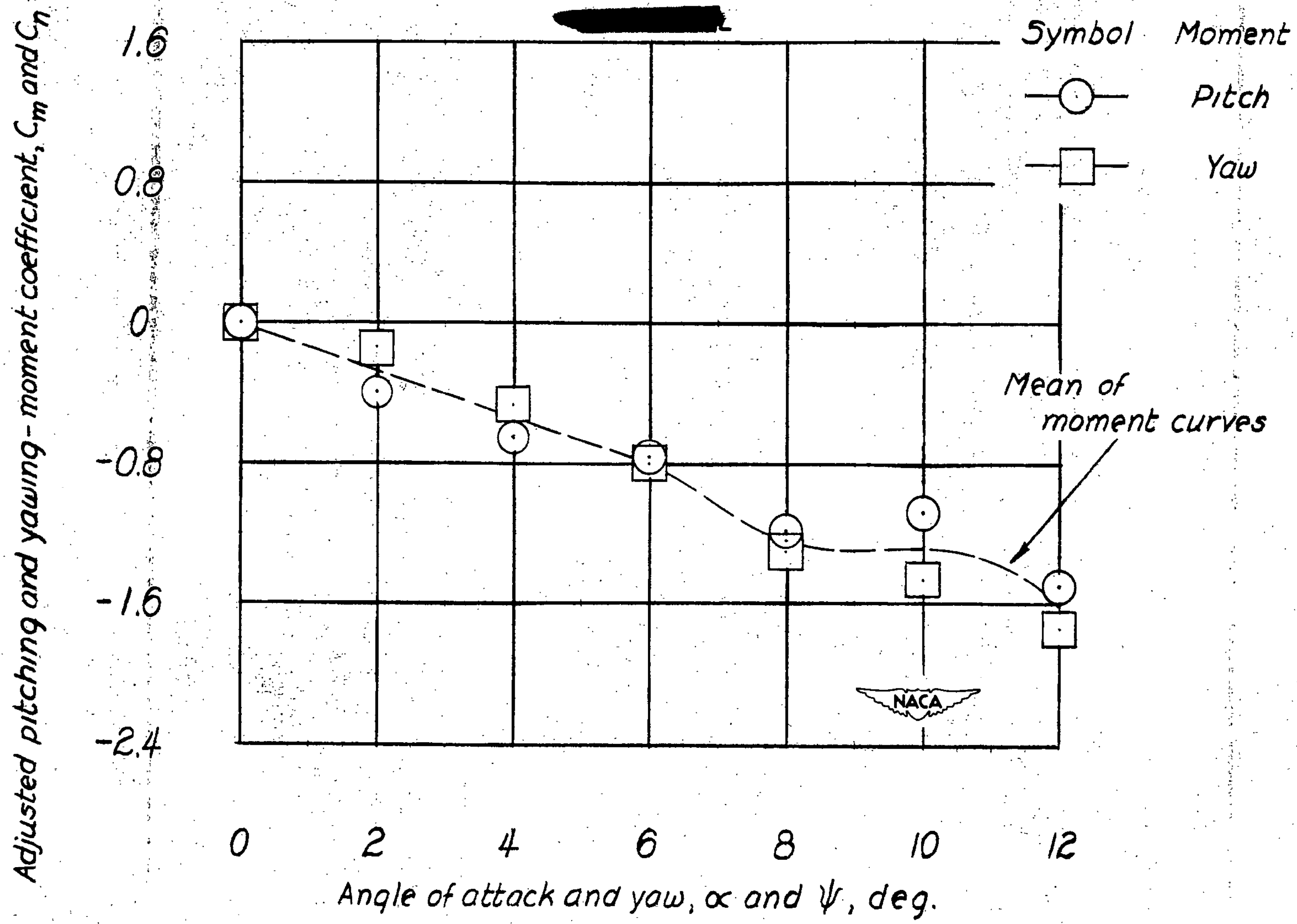


Figure 6.– Comparison of moments in pitch and in yaw for the MX-904 missile. $q$ = 159 pounds per square foot.

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